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IN THE UNITES STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

KOICHI SAKAMOTO, ET AL. : EXAMINER: SHEVIN, MARK L.

SERIAL NO: 10/564,061 :

FILED: JANUARY 10, 2006 : GROUP ART UNIT: 1793

FOR: METHOD FOR PRODUCING HIGH CLEANNESS STEEL EXCELLENT IN FATIGUE STRENGTH OR COLD WORKABILITY :

DECLARATION UNDER 37 CFR 1.132

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

SIR:

I, Koichi SAKAMOTO, a citizen of Japan,

hereby declare and state that;

1. I am a co-inventor of the above-identified application.

2. The attached Tables 1, 2, 3 and 4 are the Tables 1, 2, 3 and 4 mentioned in the specification at [0065], [0066], [0073] and [0074], respectively.

3. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

4. Further declarant saith not.

Date: September 22, 2008 Koichi Sakamoto

Koichi SAKAMOTO, Dr.Eng.
Declarant's Name (typed)

Attached: Tables 1,2,3 and 4

TABLE 1

Sample No.	Composition								Li adding method				Li content of steel /Si content of steel (% by mass)	Li_2O content of slag (% by mass)	Number of oxide inclusion particles of 20 μm or above (Number per 50g of steel)	Drawability (Frequency of breakage)	Size of the largest inclusion particle (μm)
	C	Si	Mn	Al	Ca	Mg	O	Li	Li-containing material	Adding time	Adding position	Adding method					
	(% by mass)				(ppm)												
A1	0.72	0.21	0.52	0.003	10.1	0.7	10	0.030	Li_2CO_3	After the steel melting process	Ladle	Wire	1.43×10^{-5}	0.3	0.20	5	20
A2	0.70	0.20	0.52	0.004	13.1	1.0	13	0.105	Li_2CO_3+Ca	After the steel melting process	Ladle	Wire	5.25×10^{-5}	0.2	0.18	6	18
A3	0.73	0.20	0.49	0.003	13.0	1.2	15	0.240	Li_2CO_3	After the steel melting process	Ladle	Wire	1.20×10^{-4}	0.1	0.21	6	18
A4	0.72	0.18	0.49	0.003	12.5	0.8	14	0.320	Li_2CO_3+Ca,Na, K	After the steel melting process	Ladle	Wire	1.78×10^{-4}	0.2	0.10	2	17
A5	0.83	0.21	0.52	0.004	14.5	0.8	16	0.460	Li_2CO_3	After the steel melting process	Ladle	Injection	2.19×10^{-4}	0.1	0.09	0	15
A6	0.83	0.20	0.50	0.003	14.1	2.5	15	0.665	Li_2CO_3+Ca, Mg	After the steel melting process	TD	Injection	3.35×10^{-4}	-	0.23	5	16
A7	0.82	0.22	0.50	0.003	15.1	0.9	15	0.520	Li_2CO_3+Ca	After the steel melting process	MD	Wire	3.36×10^{-4}	-	0.18	1	16
A8	0.82	0.22	0.51	0.003	12.1	1.1	14	0.870	Li-70% Si alloy	After the steel melting process	Ladle	Injection	3.95×10^{-4}	0.3	0.16	3	18
A9	0.81	0.20	0.50	0.004	15.8	2.3	15	1.210	Li-75% Si alloy	After the steel melting process	TD	Wire	6.05×10^{-4}	0.5	0.13	5	15
A10	0.83	0.21	0.52	0.003	14.1	2.7	14	1.750	Li-70% Si alloy + Ca, Mg	After the steel melting process	Ladle	Wire	8.33×10^{-4}	0.5	0.25	8	18
A11	0.83	0.22	0.50	0.003	15.0	2.5	15	1.970	Li-60% Si alloy	After the steel melting process	Ladle	Wire	8.95×10^{-4}	0.6	0.19	6	20
A12	0.72	0.21	0.52	0.003	23.8	1.8	24	13.200	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Wire	6.29×10^{-3}	1.7	1.02	48	45
A13	0.73	0.22	0.52	0.003	19.8	1.4	21	11.200	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Wire	5.09×10^{-3}	2.6	1.02	37	35
A14	0.83	0.22	0.51	0.003	24.3	1.7	25	20.200	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Wire	9.18×10^{-3}	4.1	1.20	60	41
A15	0.83	0.20	0.51	0.004	22.9	3.7	25	0.018	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Input	9.00×10^{-6}	5.2	1.10	51	39
A16	0.81	0.25	0.50	0.003	9.6	0.7	10	10	Li_2O-containing slag	Initial stage of the steel melting process	Ladle	Alloy input	0.004	10.0	2.50	87	52
A17	0.82	0.25	0.50	0.003	14.5	1.4	18	0.017	2% Li-90% Si-0.5% Al	Initial stage of the steel melting process	Ladle	Alloy input	6.80×10^{-6}	1.5	1.10	54	42
A18	0.82	0.25	0.50	0.003	12.1	1.1	17	0.018	5%Li-89% Si-0.l% Al	Initial stage of the steel melting process	Ladle	Input	7.20×10^{-6}	1.0	1.05	51	39
A19	0.73	0.23	0.52	0.003	10.4	1.5	21	0.008	LiF	Initial stage of the steel melting process	Ladle	Input	3.48×10^{-6}	1.2	1.20	56	34
A20	0.72	0.20	0.52	0.004	9.2	1.1	17	0.011	LiF	Initial stage of the steel melting process	Ladle	Input	5.50×10^{-6}	1.6	1.29	54	32
A21	0.81	0.19	0.51	0.004	8.5	1.0	16	0.014	LiF	Initial stage of the steel melting process	Ladle	Input	7.37×10^{-6}	1.7	1.14	49	32
A22	0.82	0.21	0.51	0.003	10.1	1.7	22	0.005	LiF	Initial stage of the steel melting process	Ladle	Input	2.38×10^{-6}	0.0	1.26	55	32
A23	0.82	0.25	0.50	0.003	9.9	1.6	20	0.018	Na_2SiO_3 + LiF	Before the steel melting process	Ladle	Input	7.20×10^{-6}	4.1	2.01	60	41

TABLE 2

Sample No.	Composition											Alkaline metal addidng method				Li content of steel /Si content of steel (% by mass)	Li_2O content of slag	Fatigue strength (Fracture ratio)	Fracture causing inclusion	Size of the largest inclusion particle
	C	Si	Mn	Al	Cr	N	V	Ca	Mg	O	Li	Li-containing material	Adding time	Adding position	Adding method					
	(% by mass)							(ppm)									(% by mass)	(%)		(μm)
B1	0.55	1.45	0.71	0.004	0.70	-	-	10.2	1.0	10	0.020	Li_2CO_3	After the steel melting process	Ladle	Wire	1.38×10^{-6}	0.1	4	SiO_2-rich	15
B2	0.55	1.46	0.70	0.003	0.71	-	-	18.1	1.4	18	0.330	Li_2CO_3+Ca	After the steel melting process	Ladle	Wire	2.26×10^{-5}	0.1	0	MgO-SiO_2	12
B3	0.55	1.46	0.70	0.003	0.71	-	-	22.0	1.8	24	1.190	Li_2CO_3	After the steel melting process	Ladle	Wire	8.15×10^{-5}	0.1	1	MgO-SiO_2	15
B4	0.55	1.46	0.70	0.003	0.71	0.25	0.10	17.3	3.3	22	0.624	Li2CO3+Ca, Mg	After the steel melting process	Ladle	Wire	4.27×10^{-5}	0.2	0	-	0
B5	0.58	1.45	0.70	0.004	0.70	0.25	0.10	16.1	4.3	21	0.986	Li_2CO_3	After the steel melting process	Ladle	Injection	8.80×10^{-5}	0.3	0	-	0
B6	0.60	1.46	0.70	0.005	0.70	0.25	0.10	20.9	5.1	21	0.815	Li_2CO_3	After the steel melting process	Ladle	Injection	5.58×10^{-5}	0.4	2	Al_2O_3-rich	16
B7	0.63	1.45	0.65	0.003	0.65	-	0.09	19.8	1.3	21	0.893	Li_2CO_3	After the steel melting process	TD	Wire	6.16×10^{-3}	0.2	0	-	0
B8	0.65	1.45	0.65	0.004	0.65	-	0.09	19.0	1.6	20	1.708	Li_2CO_3	After the steel melting process	MD	Wire	1.18×10^{-4}	0.3	3	CaO-SiO_2	13
B9	0.63	1.45	0.65	0.003	0.65	-	0.09	24.3	7.5	25	5.300	Li-70% Si alloy	After the steel melting process	Ladle	Wire	3.66×10^{-4}	0.3	3	Al_2O_3-rich	15
B10	0.64	1.46	0.64	0.004	0.65	-	0.09	23.1	4.1	22	13.00	Li-70% Si alloy + Ca	After the steel melting process	Ladle	Wire	8.90×10^{-4}	0.3	4	Refractory base	21
B11	0.60	2.00	0.89	0.005	0.90	0.25	0.10	17.8	3.2	19	0.470	Li_2CO_3	After the steel melting process	Ladle	Wire	2.35×10^{-5}	0.2	1	SiO_2-rich	20
B12	0.61	2.01	0.90	0.005	0.90	0.25	0.10	17.1	2.8	19	3.887	Li-70% Si alloy+Ca, Mg	After the steel melting process	Ladle	Wire	1.93×10^{-4}	0.1	3	Al_2O_3-rich	16
B13	0.61	2.01	0.90	0.005	0.90	0.25	0.10	15.0	1.1	15	0.510	Li_2CO_3	After the steel melting process	Ladle	Wire	2.54×10^{-5}	0.2	2	MgO-SiO_2	17
B14	0.61	2.01	0.90	0.005	0.90	0.25	0.10	20.2	1.4	19	2.110	Li-70% Si alloy	After the steel melting process	Ladle	Wire	1.05×10^{-4}	0.3	2	MgO-SiO_2	14
B15	0.61	2.01	0.90	0.005	0.90	0.25	0.10	21.0	1.0	21	5.90	Li-70% Si alloy	After the steel melting process	TD	injection	2.94×10^{-4}	0.3	3	Refractory base	19
B16	0.61	2.01	0.90	0.005	0.90	0.25	0.10	20.7	1.6	22	8.10	Li-70% Si alloy	After the steel melting process	Ladle	Injection	4.03×10^{-4}	0.2	2	Refractory base	18
B17	0.61	2.01	0.90	0.005	0.90	0.25	0.10	17.0	2.7	18	9.20	Li-70% Si alloy	After the steel melting process	TD	Wire	4.58×10^{-4}	0.1	4	Refractory base	19
B18	0.61	2.01	0.90	0.005	0.90	0.25	0.10	38.0	8.8	30	19.90	Li-70% Si alloy	After the steel melting process	MD	Wire	9.90×10^{-4}	0.3	5	Refractory base	21
B19	0.58	1.45	0.71	0.003	0.71	-	-	9.1	0.9	21	0.009	LiF	Initial stage of the steel melting process	Ladle	Wire	6.21×10^{-7}	0.1	35	SiO_2-rich	38
B20	0.55	1.46	0.73	0.004	0.70	-	-	23.2	4.0	24	20.20	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Wire	1.38×10^{-3}	3.0	46	Refractory base	48
B21	0.58	1.45	0.71	0.003	0.68	0.25	0.10	8.0	0.7	17	0.010	LiF	Initial stage of the steel melting process	Ladle	Wire	6.90×10^{-7}	0.2	37	SiO_2-rich	39
B22	0.58	1.46	0.71	0.004	0.70	0.25	0.10	19.9	4.0	21	2.140	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Injection	1.47×10^{-2}	7.0	54	Refractory base	48
B23	0.63	1.45	0.65	0.003	0.65	-	0.09	7.2	0.8	16	0.018	Li-95% Si alloy	Initial stage of the steel melting process	Ladle	Wire	1.24×10^{-8}	0.3	39	SiO_2-rich	41
B24	0.65	1.45	0.65	0.004	0.65	-	0.09	25.1	4.0	25	21.80	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Wire	1.50×10^{-3}	5.0	51	Refractory base	60
B25	0.60	2.00	0.89	0.005	0.90	0.25	0.10	8	0.9	22	0.012	Lif	Initial stage of the steel melting process	Ladle	Wire	6.00×10^{-7}	0.2	45	SiO_2-rich	50
B26	0.60	2.00	0.89	0.005	0.90	0.25	0.10	20.2	3.0	19	23.00	Li-70% Si alloy	Initial stage of the steel melting process	Ladle	Wire	1.17×10^{-3}	4.0	60	Refractory base	53

TABLE 3

Sample No.	Component content (% by mass)				Composition of inclusion (% by mass)								Li adding method		Number of oxide inclusion particles of 20 μm or above (Number per 50g of steel)	Drawability (Frequency of breakage)	Size of the largest inclusion particle (μm)
	C	Si	Mn	Al	CaO	SiO_2	MgO	Al_2O_3	Na_2O	K_2O	Li_2O	$Na_2O+K_2O+Li_2O$	Li-containing material	Adding time			
A24	0.72	0.21	0.52	0.003	39.8	39.3	2.1	18.1	0.0	0.0	0.7	0.7	Li_2CO_3	Final stage of the steel melting process	0.20	10	22
A25	0.82	0.19	0.51	0.004	37.2	39.0	3.7	16.0	0.0	0.0	4.1	4.1	Li-70% Si alloy	Final stage of the steel melting process	0.10	5	19
A26	0.81	0.21	0.50	0.003	20.8	41.9	2.1	15.6	3.4	4.1	12.1	19.6	Li-70% Si alloy	Final stage of the steel melting process	0.09	2	17
A27	0.72	0.18	0.49	0.003	29.0	45.0	18.0	3.0	0.0	1.0	3.0	4.0	Li-70% Si alloy	Final stage of the steel melting process	0.16	6	20
A28	0.72	0.21	0.52	0.004	15.0	47.4	9.2	16.0	2.3	0.0	10.1	12.4	Li-70% Si alloy	Final stage of the steel melting process	0.13	7	18
A29	0.83	0.19	0.50	0.003	20.1	63.1	1.8	8.0	0.5	2.6	3.9	7.0	Li-70% Si alloy	Final stage of the steel melting process	0.19	11	22
A30	0.84	0.20	0.48	0.003	26.4	32.0	2.5	34.0	0.0	0.0	5.1	5.1	Li-70% Si alloy	Final stage of the steel melting process	0.21	9	21
A31	0.70	0.18	0.49	0.003	30.0	58.0	1.6	10.0	0.0	0.0	0.4	0.4	Li_2CO_3	Initial stage of the steel melting process	0.80	31	32
A32	0.73	0.20	0.51	0.003	25.0	39.0	1.0	14.0	0.0	0.0	21.0	21.0	Li-70% Si alloy	Initial stage of the steel melting process	0.55	28	41
A33	0.73	0.21	0.50	0.004	55.2	25.0	2.2	16.6	1.0	0.0	0.0	1.0	-	-	0.67	35	45
A34	0.74	0.20	0.50	0.003	14.0	61.0	2.5	21.3	0.0	1.2	0.0	1.2	-	-	0.45	40	36
A35	0.81	0.19	0.52	0.003	28.7	31.0	3.4	36.0	0.0	0.0	0.9	0.9	Li_2CO_3	Initial stage of the steel melting process	0.38	24	31
A36	0.83	0.20	0.49	0.004	11.0	50.7	20.5	16.2	0.6	0.0	1.0	1.6	Li_2CO_3	Initial stage of the steel melting process	0.54	46	37
A37	0.83	0.20	0.50	0.003	15.0	71.0	3.9	8.1	0.5	0.4	1.1	2.0	Li_2CO_3	Initial stage of the steel melting process	0.93	58	39
A38	0.83	0.19	0.51	0.004	45.0	18.0	2.6	33.4	0.0	0.4	0.6	1.0	Li_2CO_3	Initial stage of the steel melting process	0.41	22	32

TABLE 4

Samplo No.	Component content (% by mass)							Composition of inclusion (% by mass)								Li adding method		Fracture ratio (%)	Inclusion causative of fracture	Size of the largest inclusion particle (μm)
	C	Si	Mn	Al	Cr	Ni	V	CaO	SiO_2	MgO	Al_2O_3	Na_2O	K_2O	Li_2O	$Na_2O+K_2O+Li_2O$	Adding position	Adding time			
B27	0.55	1.45	0.71	0.004	0.70	-	-	35.0	42.7	2.9	18.8	0.0	0.0	0.6	0.6	Li_2CO_3	Final stage of the steel melting process	18	$MgO-SiO_2$	25
B28	0.58	1.46	0.70	0.003	0.71	0.25	0.10	35.2	40.5	2.7	18.0	0.0	1.0	2.6	3.6	Li_2CO_3	Final stage of the steel melting process	0	-	-
B29	0.58	1.45	0.70	0.004	0.70	0.25	0.10	25.6	41.5	17.3	10.2	1.2	0.0	4.2	5.4	Li_2CO_3	Final stage of the steel melting process	0	-	-
B30	0.60	1.46	0.70	0.005	0.70	0.25	0.10	22.4	37.8	2.4	33.8	0.0	0.0	3.6	3.6	Li_2CO_3	Final stage of the steel melting process	8	Al_2O_3-rich	16
B31	0.63	1.45	0.65	0.003	0.65	-	0.09	21.2	40.2	2.5	28.6	2.1	1.5	3.9	7.5	Li_2CO_3	Final stage of the steel melting process	0	-	0
B32	0.65	1.45	0.65	0.004	0.65	-	0.09	36.3	46.0	5.6	4.9	0.0	0.0	7.2	7.2	Li-70% Si alloy	Final stage of the steel melting process	3	$CaO-SiO_2$	13
B33	0.60	2.00	0.89	0.005	0.90	0.25	0.10	18.0	69.8	2.8	7.2	0.0	0.0	2.2	2.2	Li_2CO_3	Final stage of the steel melting process	18	SiO_2-rich	25
B34	0.61	2.01	0.90	0.005	0.90	0.25	0.10	15.1	45.0	2.2	19.5	0.0	0.0	18.2	18.2	Li-70% Si alloy	Final stage of the steel melting process	5	Al_2O_3-rich	16
B35	0.55	1.44	0.69	0.003	0.70	-	-	21.5	60.3	2.9	13.2	0.0	0.0	2.1	2.1	Li_2CO_3	Final stage of the steel melting process	0	$MgO-SiO_2$	18
B36	0.58	1.46	0.70	0.003	0.71	0.25	0.10	20.3	65.2	2.4	10.2	0.0	0.0	1.9	1.9	Li_2CO_3	Final stage of the steel melting process	3	$MgO-SiO_2$	19
B37	0.63	1.45	0.65	0.003	0.65	-	0.08	20.2	63.8	2.9	7.2	0.0	0.0	5.9	5.9	Li-70% Si alloy	Final stage of the steel melting process	0	$MgO-SiO_2$	16
B38	0.60	2.00	0.89	0.005	0.90	0.25	0.10	19.0	62.5	2.8	9.2	0.0	0.0	6.5	6.5	Li-70% Si alloy	Final stage of the steel melting process	0	$MgO-SiO_2$	0
B39	0.56	1.45	0.71	0.003	0.71	-	-	19.2	64.8	2.4	13.2	0.0	0.0	0.4	0.4	Li_2CO_3	Initial stage of the steel melting process	35	SiO_2-rich	32
B40	0.55	1.46	0.73	0.004	0.70	-	-	20.9	43.1	2.5	12.3	0.0	0.0	21.2	21.2	Li-70% Si alloy	Initial stage of the steel melting process	75	Refractory base	48
B41	0.55	1.46	0.68	0.005	0.70	-	-	15.0	45.0	2.3	16.2	2.5	1.2	17.8	21.5	Li-70% Si alloy	Initial stage of the steel melting process	89	Refractory base	67
B42	0.58	1.45	0.71	0.003	0.68	0.25	0.1	55.9	32.6	2.1	8.4	0.0	0.0	1.0	1.0	Li_2CO_3	Initial stage of the steel melting process	35	CaO-rich	35
B43	0.58	1.46	0.71	0.004	0.70	0.25	0.1	14.0	62.3	1.9	21.0	0.0	0.0	0.8	0.8	Li_2CO_3	Initial stage of the steel melting process	46	SiO_2-rich	43
B44	0.55	1.46	0.71	0.003	0.70	-	-	22.4	39.7	1.7	35.1	0.0	0.0	1.1	1.1	Li_2CO_3	Initial stage of the steel melting process	36	Al_2O_3-rich	30
B45	0.63	1.45	0.65	0.003	0.65	-	0.09	29.2	30.0	1.5	36.0	0.0	0.0	1.3	1.3	Li_2CO_3	Initial stage of the steel melting process	35	Al_2O_3-rich	34
B46	0.65	1.45	0.65	0.004	0.65		0.09	16.4	53.1	20.1	9.3	0.0	0.0	1.1	1.1	Li_2CO_3	Initial stage of the steel melting process	51	$MgO-SiO_2$	32
B47	0.61	2.01	0.90	0.005	0.90	0.25		16.0	71.8	2.7	8.6	0.0	0.0	0.9	0.9	Li_2CO_3	Initial stage of the steel melting process	66	SiO_2-rich	45
B48	0.60	2.00	0.89	0.005	0.90	0.25	0.1	53.5	18.9	2.9	23.7	0.0	0.0	1.0	1.0	Li_2CO_3	Initial stage of the steel melting process	38	CaO-rich	48